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PROJECT CHECO SOUTHEAST ASIA REPORT

JAN-JUN 67

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PROJECT CHECO REPORT

Contemporary Historical Evaluation of Combat Operations

AIR·TO·AIR ENCOUNTERS OVER NORTH VIETNAM

1 January - 30 June 1967

30 NOVEMBER 1967

HQ PACAF

Directorate, Tactical Evaluation
CHECO Division

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Prepared by:

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REPLY TO ATTN OF: DTEC

30 November 1967

SUBJECT: Project CHECO Report, "Air-to-Air Encounters Over North Vietnam, 1 January - 30 June 1967" (U)

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FOR THE COMMANDER IN CHIEF

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FOREWORD

Air-to-air engagements over North Vietnam (NVN) during the first six months of 1967 were marked by an intensity of battle unmatched in the entire two previous years of airstrikes to the north. In this one six-month period, USAF pilots downed 46 MIG aircraft, which represents 75 percent of the total kills to date. As evidence of the increased use of MIG-17 and MIG-21 aircraft, five more USAF planes were downed bringing the total USAF air-to-air losses to 12. 1/

The period is significant not only for the rise in MIG activity but for the marked desire to use the MIG weapons systems for active air defense. Noteworthy developments in fighter aircraft tactics by the North Vietnamese Air Force (NVNAF) and the United States resulted from the lessons learned during these engagements. To leave the description of air encounters to a comparison of kills, would slight many other factors that influence air-to-air combat. Evaluating the expanded NVNAF commitment to air defense, along with other defense capabilities, gives a perspective for the actual threat posed by MIG aircraft to the U.S. Air Force.

CHAPTER I

MIG ROLE BEFORE 1967

MIG fighter aircraft did not pose a serious threat in the Vietnam conflict before the last quarter of 1966, as only sporadic, unpredictable contact took place between them and U.S. aircraft. The big threats to strike aircraft were active SAM and AAA/AW defense. The MIG threat was only a potential factor, since active opposition in the air was unusual.

The first MIG attack on 4 April 1965 resulted in the loss of two F-105s, the only USAF aircraft downed that year by enemy aircraft. On 10 July 1965, two F-4Cs, manned by Capt. Kenneth Holcombe and his pilot, Capt. Arthur Clark, and Capt. Thomas Roberts, with his pilot, Capt. Ronald Anderson, each downed a MIG-17. 1/

Although the MIG-15/17 force was in-being before continuing airstrikes by U.S. forces in early 1965, and the NVNAF had received some MIG-21s, no other significant engagements occurred that year. After June 1965, modified versions of the MIG-21s, equipped with Atoll infrared homing missiles arrived, but a marked reluctance existed for committing this jet fighter force to other than defensive patrols over the Hanoi area. 2/

In the first eight months of 1966, 11 MIGs had been shot down (with a loss of only three USAF aircraft). 3/ They were primarily engaged in feigned attacks for combat training purposes, with GCI controllers positioning the interceptors for stern attacks. The MIGs completed a dry firing pass and

usually broke off before engaging in combat. This operational training, however, facilitated the integration of GCI and MIG systems into a mature interceptor capability. 4/

Accordingly, by the last quarter of 1966, a significant change took place as MIG activity and aggressiveness increased. The effectiveness of the QRC-160 ECM pod, 5/ introduced late in 1966, led to a decrease in defense capability from the ground, and increased air activity. 6/

From 4 September, with the exception of four days, until January 1967, the MIG was flown every day, marking the first continuous use of these aircraft as active defense weapons. NVN intentions to employ the MIG force fully, so as to reduce strike effectiveness, resulted in the loss of four additional USAF aircraft. 7/

As evidence of the improvement in air defense, reconnaissance photographs revealed an upgrade in the quality of NVNAF equipment with the introduction of modified MIG-21 D or F models. With the resolve to use the MIG against U.S. operations, a greater reliance was noted on the use of air-to-air missiles. The first loss to an AAM, an F-105 strike aircraft, occurred on 14 December 1966. 8/

The MIG weapons system had now become more than a potential threat as increased NVNAF activity began to compromise strike missions and affect the security of the strike force. MIG confrontations necessitated the jettisoning of ordnance as strike flights were forced into defense maneuvers. Operating from five airfields, Phuc Yen, Kep, Hanoi/Gia Lam, Haiphong/

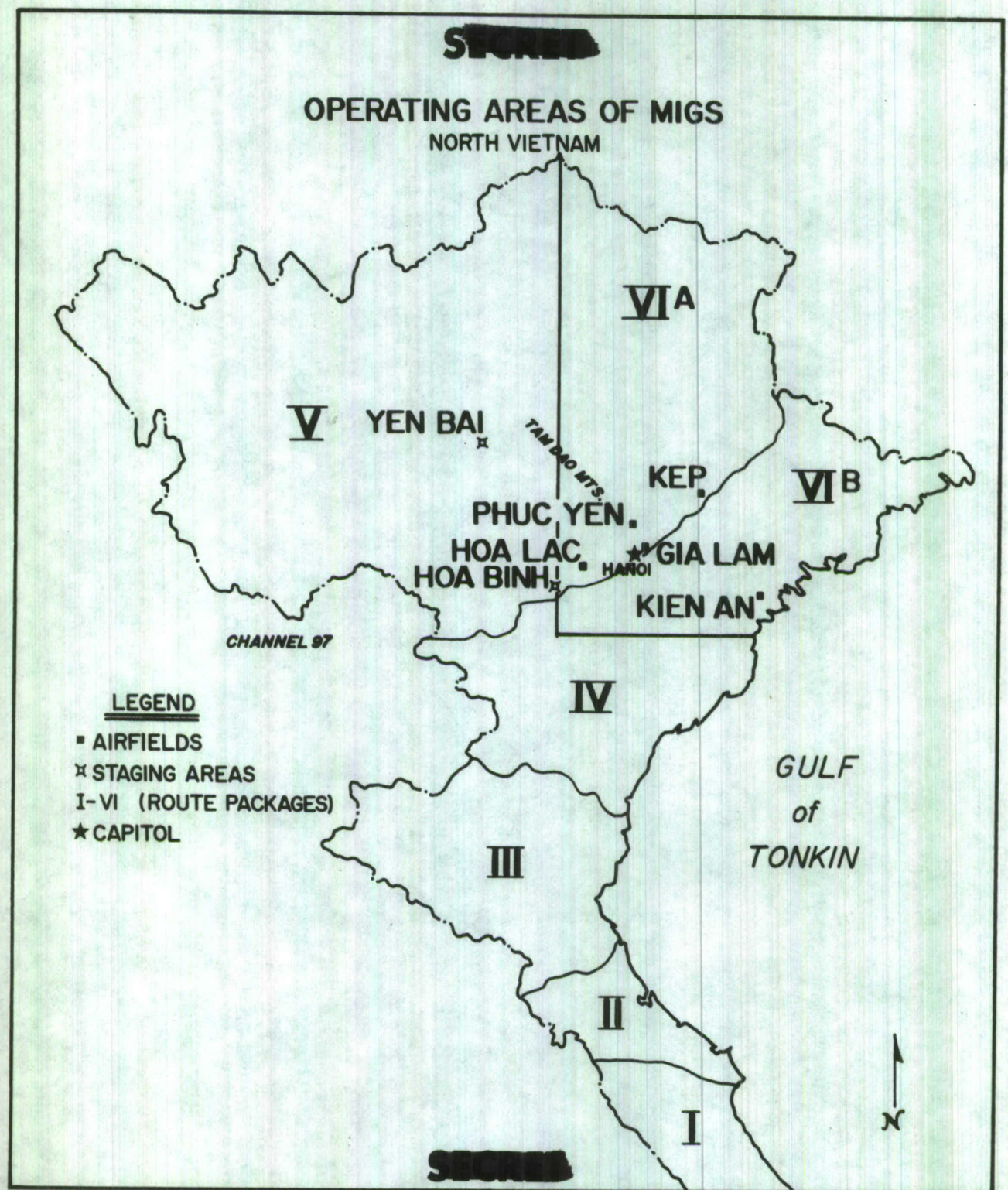

SECRET
OPERATING AREAS OF MIGS
NORTH VIETNAM
VI A
V
YEN BAI
TAM DAO MTS.
KEP
VI B
PHUC YEN
HOA LAC
HANOI
GIA LAM
HOA BINH
KIEN AN
CHANNEL 97
IV
LEGEND
AIRFIELDS
STAGING AREAS
I-VI (ROUTE PACKAGES)
CAPITOL
GULF
of
TONKIN
III
II
I
N
SECRET

Figure 1

Kien-An, and Hoa Lac, the MIGs enjoyed a certain degree of immunity while on the ground. The political restriction barring strike forces from hitting enemy airfields was to exist until 23 April 1967. 9/

Use of the MIG as an integral part of the total NVN air defense system became an important consideration of operational strategy by 1967. The threat of counterair activity had become a reality, and U.S. fighter pilots would be called upon to drive that threat from the sky for the preservation of strike aircraft.

CHAPTER II

ENVIRONMENT

An important consideration in air-to-air combat is the environment in which the action takes place. Until 23 April 1967, the MIGs had a relative freedom of operation in that their home bases had never been struck. Further, in Route Packages, 5 and 6, where MIG activity is most intense, SAMs, AAA/AW have also been concentrated. While operating in this hostile environment, our forces are a considerable distance from their home base. No other air war has exposed U.S. aircrews to AAA, SAMs and MIGs in the same airspace simultaneously.[1/]

To more thoroughly understand the role played by the MIGs in this environment, it is necessary to analyze the coordination of the other types of air defenses, the radars they employ as well as the aircraft itself. North Vietnam has a collection of old and new Soviet-supplied electronic equipment, and has established an extensive radar network which permits their counterair weapons systems to complement each other. Whenever U.S. pilots are in this environment, they must be aware of the everpresent dangers as this pilot discovered:[2/]

> *"Oddly enough, while they were firing at us (the MIGs), people on the ground were firing at us. Most people will say that if you are engaging the MIGs, nobody from the ground will be shooting at you. Well, this isn't true up there. They will fire at you. It surprised me when I first saw it because I didn't think they would."*

Radars

Radars for the antiaircraft artillery systems in NVN provide early warning, but less than half of the actual gun sites appears to have them. Controlled by optical range-finder inputs, weapons are of three types: (1) Automatic Weapons (AW), usually 12.7-mm or 14.5-mm, having an extremely high rate of fire; (2) Light AA Weapons are 37-mm and 57-mm--targets up to 600 KTAS at a range of 5,500 meters can be tracked by optical-mechanical computing sites of this type; and (3) Medium Weapons consist of 85-mm or 100-mm guns. 3/

The main types of radars are: 4/

Early Warning (EW) - BARLOCK, TALL KING.

Height-Finding - ROCK CAKE, STONE CAKE, SPONGE CAKE or SIDE NET.

V-Beam for EW and GCI backup (used as high sortie handling, search radar) - TOKEN or BIG MESH.

VHF EW backup (Medium, high altitude acquisition gap-filler) - KNIFE REST, SPOON REST.

Limited low altitude coverage capability (acquisition) - FLAT FACE.

Ground fire control - FANSONG B, FIRECAN, WHIFF.

Weakness of Radars

The major weakness of enemy radars is their limited capability to acquire and track low-flying aircraft. Normally EW radars are limited to line of sight and terrain masking and ground clutter decrease their capability for tracking over land areas. Until recently, NVN possessed moderate numbers of EW radars, most of which are obsolescent. The addition of more

FLAT FACE and SPOON REST, plus several BARLOCK radars, have considerably improved the EW capability. With the exception of some of the KNIFE REST types, the older EW radars are vulnerable to countermeasures. Three of the height-finders--ROCK CAKE, STONE CAKE, and SIDE NET--recently furnished by the Soviets, are the principal equipment which provides an altitude determining capability for the entire area of responsibility. 5/

Soviet doctrine placed the MIG force out in front of the SAMs, but the NVNAF chose to combine these two defenses. Before the introduction of the QRC-160 pods in 1967, U.S. strike aircraft were operating at altitudes of about 4,000 feet because of the SAM threat, thus being vulnerable to single-pass, diving attacks by the gun-armed MIG. 6/ (After a short learning period after the introduction of the QRC-160 pods, the ingress altitudes were higher. Korat aircraft, for example, operated at 15,000 to 17,000 feet. Takhli aircraft began increasing altitude at a slower rate, starting generally 6,500 feet above ground and increasing gradually until June 1967, when they were operating at from 8,000 to 12,000 feet.) The number of attacks of this type in January substantiates this tactic. 7/

As an example, environment influenced the pilot in the following encounter to elect a turning battle against the more maneuverable MIG-17, rather than disengage immediately and face the SAM: 8/

> *"...We were inhibited from using maximum performance of the F-4 because of the dangerous SAM threat. We had already heard that the flight that had preceded me was knocked down by a SAM. One thing we certainly didn't want to do was climb up into the SAM envelope as a single*

F-4C
Figure 2

aircraft because you are sure to get picked off. What this forced us to do was go into a turning battle with MIG-17s, which frankly is the worst thing you can do."

In this battle, the lone third man of the flight was sent home, while Lead and Two kept the MIGs distracted, then later they escaped. To overcome the SAMs, U.S. IRON HAND and WILD WEASEL crews employ a specially configured multi-place fighter aircraft and specially trained crews to hunt and kill enemy radar controlled surface-to-air sites in NVN. The flights, carrying two AGM-45 Shrike missiles, are directed primarily at the SAM. 9/

On 21 January 1967, Panda Flight (four F-105s, flying IRON HAND support) was at 4,000 feet altitude when it was jumped by five, possibly eight, MIG-17s. Panda Four had just launched a Shrike at a FANSONG signal when the MIGs made cannon passes on all four members of the flight. With one to two MIGs on each aircraft, Panda Flight dropped ordnance and jinked right, left, then down. Panda Four sustained damage from cannon fire in the left wing and flap. Despite the MIGs concentration on Panda Two, who was having afterburner trouble and falling behind, all aircraft did recover at home base. 10/ The QRC-160 ECM pods tie the strike flights into a less maneuverable formation; however, it is chosen because it provides optimum protection from all ground and air threats that the strike aircraft might encounter. Maj. Dale W. Lathem, Chief of the 355th TFW's Stand/Eval, Takhli, described the importance of this formation: 11/

"With our force going in, we are very dependent on the pod for protection from the SAM since anytime we get into the Package VI area, we are in...SAM Valley and always under scrutiny. The pod formation is extremely important...It's important to hold this pod formation which is not a real

maneuverable or defensive counterair formation. We are also providing, we feel, adequate six o'clock coverage due to the half-mile or so lateral separation between flights."

The requirement of having sufficient fuel to recover to the tanker force is also dictated by the environment. The fuel that must be carried adds even more weight to the already heavy U.S. aircraft, limiting the agility against the lighter MIGs. The NVNAF can afford an afterburner engagement because of the short distance to their recovery bases.

CHAPTER III

FIRST ACTION IN 1967

The steady increase of MIG aircraft flying activities, beginning late in 1966, represented a threat to strike flights which had to be contained. Operation BOLO, conducted on 2 January 1967, challenged MIG activity and resulted in downing seven MIG-21s--nearly half of Hanoi's force--without a single U.S. loss. [1]

Operation BOLO

Operation BOLO was the first offensive fighter sweep of the Vietnamese conflict. [2] Col. Robin Olds, Commander, 8th Tactical Fighter Wing (TFW), was given the responsibility for planning and executing the mission. Contributing to the success of this operation was the support of EB-66 ELINT/ECM forces, tanker forces, BIG EYE Task Force, rescue forces, C-130 support organizations, GCI, and the 366th, 355th, and 388th TFWs.

Because MIG attacks in the last quarter of 1966 had forced many strike flights to jettison bomb loads before reaching their target, and later model MIG-21s had the capability of carrying radar-guided or heat-seeking missiles, they had become a real threat as well as harassment factor to U.S. fighters. Accordingly, Operation BOLO was conceived, planned, and executed for two primary reasons: first, the recognized future threat of MIG aircraft, and second, the political restrictions which prevented strike flights from hitting enemy airfields and destroying planes on the ground. [3] The overall objective of the operation was to destroy the NVN airborne forces. [4]

In executing this operation, knowledge of consistent behavior patterns and predictable attack frequencies of the NVNAF was required in order to get the MIG pilots in the air so they could be engaged by U.S. forces. The following plan was evolved and executed, taking into consideration the capabilities and possible reaction of enemy aircraft, U.S. force capabilities, support and supply needs, and force composition. 5/

An F-4C force was configured to look like an F-105 strike force, and flew a similar mission profile. Similar tanker anchors, refueling altitudes, ingress routes, approach altitudes, airspeeds, and radio calls and communications were used to simulate the F-105 force on the NVN radars. The EB-66s flew normal formations, and the IRON HAND flights operated normally. The QRC-160 pods were rounded up and every aircraft was fitted with one. Between 30 December and 1 January, the pilots attended a series of briefings which covered all phases of operation. Utilization of the QRC-160 pods was stressed as were the areas of weaponry, RHAW, intelligence, including recognition of aircraft and their capabilities, attack tactics, all phases of air-to-air combat, with special emphasis on use of the vertical plane, and element integrity. 6/

The force itself consisted of:

1. Fourteen flights of F-4Cs.
2. Six flights of F-105 IRON HAND.
3. Four flights of F-104s.
4. Normal supporting flights of EB-66, RC-121 BIG EYE, and KC-135 tankers.

F-105
Figure 3

The time on target (TOT) of all flights was separated by five minutes to provide at least 55 minutes of F-4C coverage in the target area. It had been estimated that the MIGs could stay airborne for approximately 50 minutes with five minutes of engagement time. Two main F-4 forces--East and West--existed. The West Force, composed of flights from the 8th TFW, would get the MIGs airborne, then cover suspected orbits, as well as Phuc Yen and Gia Lam airfields. The East Force, made up of flights from the 366th TFW, Da Nang AFB, RVN, would cover Kep and Cat Bai airfields and block egress or ingress routes from the north. The first three flights of the West Force, after entering the Hanoi area, headed for known MIG orbits. 7/

The MIGs soon fell into this elaborate trap and seven MIG-21s were downed in 12 minutes with no U.S. losses. 8/ Prevailing weather conditions and communications difficulties prevented even greater success.

Certain MIG tactics were observed. Apparently under GCI control, two MIG-21s attacked from the 10-12 o'clock position while others were simultaneously vectored in from the 5-7 o'clock position. Col. Daniel "Chappie" James, Jr., described this type of tactic: 9/

> *"My flight was attacked by four MIG-21s, two from 10 o'clock high and two (simultaneously) from six o'clock low. I did not see the MIG's at first, as I had already started to counter the attack of the two closing from the front quarter....I quickly max rolled from a left bank to a steep right and observed the low MIGs called. I called a hard right break for three and four."*

The purpose of the double attack was to force the F-4 to turn from the rear encounter, allowing the MIG-21s, originally in the 12 o'clock position,

a tail-on attack.[10] Colonel Olds described this unsuccessful attack and his first MIG kill:[11]

> *"At the onset of this battle, the MIGs popped up out of the clouds. Unfortunately, the first one to pop thru came up at my six o'clock position. I think this was more by chance than design. As it turned out, within the next few moments, many others popped out of the clouds in varying positions around the clock.*
>
> *"This one was just lucky. He was called out by the second flight that had entered the area and were looking down on my flight, and saw the MIG-21 appear. I broke left, turning just hard enough to throw off his deflection, waiting for my three and four men to slice in on him. (At) the same time I saw another MIG pop out of the clouds in a wide turn about my 11 o'clock position, a mile and a half away. I went after him and ignored the one behind me. I fired missiles at him just as he disappeared into the clouds.*
>
> *"I'd seen another pop out in my 10 o'clock position, going from my right to left, in other words just about across the circle from me. When the first MIG I fired at disappeared, I slammed full afterburner and pulled in hard to gain position on this second MIG. I pulled the nose up high about 45°, inside his circle. Mind you, he was turning around to the left so I pulled the nose up high and rolled to the right. This is known as a vector roll. I got up on top of him and half upside down, hung there, and waited for him to complete more of his turn and timed it so that as I continued to roll down behind him, I'd be about 20°, angle off and about 4,500 - 5,000 feet behind him. That's exactly what happened. Frankly I am not sure he ever saw me. When I got down low and behind, he was outlined by the sun against a brilliant blue sky, I let him have two Sidewinders, one of which hit and blew his right wing off."*

During the MIG Shoot, Rambler flight, the third into the area, fought in two engagements with the MIG-21s. The first engagement began with the sighting of MIGs at the two o'clock low position. Maj. Phil Combies and

his pilot, Lt. Lee Dutton, flying Rambler Four, locked on to one MIG-21, full system with inter-locks out, and manually tracked the MIG. Drawing lead, Rambler Four fired two AIM-7s, the first of which was not observed. The second one, guiding well, detonated at the tailpipe of the MIG. After a large explosion, an immediate chute was sighted. Meanwhile Rambler Three, attacking a MIG-21, locked on at two and a half miles and launched two AIM-7s at one and a half miles. One did not track, while the other tracked until the MIG-21 climbed into a cloud prior to impact. 12/

On the second engagement, Rambler Four launched two ineffective AIM-7s. The MIG under attack maneuvered so as to allow Rambler Four to unload Gs and come into AIM-9 firing parameters. Two of these missiles were fired; one detonated to the right and high of the MIG exhaust, the other to the right and low. Rambler Three and Four broke to evade a MIG-21 firing pass and a kill could not be claimed. 13/

At the same time, a MIG-21 made a cannon firing pass between Rambler Lead and Two. After breaking up to the left, then down, Lt. Lawrence Glynn and his pilot, Lt. Lawrence Cary, positioned themselves to turn inside the two MIG-21 attackers and fired two AIM-7s at the trailing MIG. The second impacted on the MIG; a chute was sighted by another aircraft in that area and the kill was confirmed for Rambler Two. 14/

Although the MIG-21 losses on 2 January represented nearly half of Hanoi's total force of this type, the NVNAF had the capability to assemble MIG-21s which were stored in crates at Phuc Yen. 15/ Operation BOLO, however,

had established the air-to-air superiority of the F-4C pilots over their MIG-21 counterparts. In February (two additional MIG-21s were downed on 6 January), MIG pilots still showed a lack of aggressiveness. 16/

CHAPTER IV

MIG WEAPONS SYSTEM

When two aircraft weapons systems are pitted against one another in air-to-air combat, many factors influence the outcome of the engagement. Operating characteristics of the aircraft, the pilots' skill level, techniques, capabilities, and aggressiveness affect the outcome. The 8th TFW Doctrine states: 1/

> *"In air-to-air environment it is necessary for the entire crew to be as familiar with his adversary as possible. Weapon performance knowledge is essential to the crew member for the crew to take advantage of any opportunity that presents itself in combat."*

The pilot who is most likely to excel in an air combat situation is the one who is best prepared. Researching, studying, evaluating, and applying information about the enemy will prepare the pilot for this challenge. The U.S. pilot cannot be sure what the MIG pilot will do in an air-to-air encounter, how he will attack, what maneuvers he will use. Our pilots are forced into a defensive role, and skill must be relied upon to turn the tables in an engagement to force the MIG to fight our kind of battle, not their's. In a comparison of U.S. pilots with NVN pilots, Lt. Col. Robert Titus said, *"I would also say that if we were flying MIG-17s and MIG-21s, and they were coming up there in F-4s and F-105s, I think we would still have the highest score."* 2/

Knowing the capabilities and limitations of the enemy's weapons system

requires a knowledge of first, plane flight characteristics, then, the weapons that have been coupled to that particular delivery system. The pilot must also make a subjective evaluation of the enemy to determine how to use this weapons system to stay one step ahead and survive any air-to-air confrontation with this enemy.

MIG-17

Developed from the MIG-15, the Fresco-A and B MIG-17 models had improved performance characteristics which resulted in a more stable flight, a better rate of climb, and higher altitude and speed capabilities. The effect of the MIG-17 cannon is still limited because of insufficient improvement in the optical fire control system taken from the MIG-15. 3/

Basically, the MIG-17 is a single-engine fighter with a maximum range of 1,100 nautical miles, a maximum speed of 625 KT, and a service ceiling of 57,000 feet. 4/ Appearing in 1954, a small afterburner and range-only SCAN FIX radar were added to the C model. The 1955, D model possessed AI radar capability, and a non-afterburner version, the MIG-17E, appeared that year. 5/

The MIG-17 carries three guns as armament and the A, B, and C models carry one 37-mm and two 23-mm guns, while the D and E have three 23-mm weapons. All models carry air-to-air rockets but the D and E versions are the only AAM carriers. 6/

MIG-21

The Fishbed MIG-21 prototypes appeared at the 1956 Tashino Air Show. These A and B models were single-engine, gun-armed, Delta-winged fighter

MIG-21
Figure 4

interceptors. The employment of guns denoted an adherence to lead-pursuit tactics compatible with a fire control system of an optical gyro, lead-computing gunsight with range-only radar. 7/

The operational versions, C and E models, are clear air mass interceptor/attack fighters while the D and F are all-weather models. The Fishbed C, first observed in 1958, had two 16 shot 57-mm FFAR pods mounted externally, as a complement to the gun armament. When the Atoll AA-2 missile became operational in 1959, one NR-30 gun was removed from the MIG-21 as the C model employed the new missile. The armament and fire control systems noted in the E model in 1962, were identical to the earlier C variant. 8/

With the Fishbed D in late 1962, the use of the Atoll missile as main armament with the exclusion of a permanent gun installation produced a significant variant in air-to-air interceptors. The model possessed a search and track radar gunsight that permitted non-visual target tracking and missile firing. 9/

Visibility Limitation

The cockpit visibility of the Fishbed C and E, for ranges greater than 10,000 feet, is severely limited, especially if the pilot wears a pressure helmet. Since only the leading edge of the 57-degree swept-wing can be seen, the amount of maneuvering each pilot may do is very limited because the regions behind and above cannot be seen. In normal tactical formations, the lead pilot cannot see the wingman or direct the flight in more than simple maneuvers. 10/

MIG Gun Systems

The Soviet guns employed on all MIG aircraft, including those currently in use by NVN, consist of three basic weapons. All are characterized by a slow rate of fire and a limited number of rounds per aircraft load.

The NR-23, a 23-mm weapon, with an effective range of 3,500 feet, fires at a rate of 800 rounds per minute. The 80 rounds carried by the aircraft for each gun provide six seconds of fire. 11/

Two models of the N-37 weapon are used. The standard 37-mm, with a 400-round-per-minute rate of fire, carries 40 rounds per gun giving a six-second firing time. The improved N-37, carried by the Fresco-A, B, and C, the Farmer-A, and the Flashlight-A, fires 500 rounds per minute with five seconds of total fire. 12/

A new linear action 30-mm weapon has a cyclic rate of fire of 700 rounds per minute. The Farmer-C and D, Fitter, and Fishbed-A and C are reported to carry this weapon. 13/

Air-to-Air Missile Systems

Of the five types of Soviet missiles listed (Appendix II), only two have been seen in NVN. The Alkali AA-1 and the A and B improved versions are beam-riding missiles that must be guided all the way to impact. Allowable aircraft roll at launch is 15 degrees, since the launching platform must have steady-state flight characteristics. The missile is preprogrammed to pitch up into the radar beam from the launching position under the wing. The

Spin Scan search radar has a range of 10 to 15 nautical miles and a tracking range of eight nautical miles. Range of the AA-1 is 1.5 nautical miles, while the AA-1A and B can reach two to three nautical miles. Its maximum velocity is 1.7 Mach, [14] and a self-destruct mechanism terminates the usable guidance after 12 seconds. [15]

Atoll AAM

The AA-2 Atoll (K-13 and 13A by Soviet designation) infrared homing missile is a replica of our Sidewinder missile and has similar performance characteristics. [16] It is compatible with any fighter rigged to carry it, but is limited to clear air masses both day and night. [17]

Specific limitations of the Atoll are: [18]

1. At altitudes below 47,500 feet at launch, the aircraft must be in a maneuver of less than two Gs.
2. At altitudes above 47,500 feet, the aircraft launch maneuver limitation is 1.6 Gs.
3. Minimum launch range is 3,280 feet; maximum range is dependent on launch aircraft speed and quantity of target radiation.
4. The missile can make 10G maneuvers at sea level and 4G maneuvers at 50,000 feet.
5. The missile cannot guide within 30 degrees of the sun and has great difficulty from 30 to 50 degrees.
6. At altitude, launch mode is pursuit from 30 degrees above or below target and within an azimuth of 48 degrees.
7. Missile can be launched in snap-up mode but maneuver capability is degraded above 50,000 feet.

8. Ground clutter seriously degrades the ability of the missile to guide. At low level, the attacker therefore usually does not launch at a target below his altitude.

CHAPTER V

COMPARISON OF AIRCRAFT

A comparison of the MIG aircraft with F-4C and F-105 fighter aircraft provides reasons for certain tactics which have evolved in air-to-air combat. U.S. models are heavier but are equipped with large airborne radars and long-range mission capabilities, whereas the MIG-21, of lighter weight, serves as a high-performance interceptor with limited range and radar capability.[1] The Soviets, since World War II, concentrated on "higher and faster" potential, but in accomplishing this goal, they sacrificed range,[2] using the following philosophy:

* Most Soviet fighters are capable of operating from sod airfields that are located close to a battle zone and therefore may perform their mission without great range.

* Soviet fighters are designed for "Defense of the Homeland" and are intended to operate close to friendly airfields.

The design of the MIG-21 has not resulted in a far superior aircraft, since airmanship of the F-4Cs and F-105s exploits deficiencies known to exist in the MIG-21.

MIG-17 Fresco

The basic advantage of the MIG-17 aircraft is a very short turn radius. Experienced U.S. pilots, who have engaged the MIG-17 in air-to-air combat, are also aware of its low-wing loading and excellent cockpit visibility which enables it to defend itself quite capably in a turning battle.[3]

Colonel Olds said: [4]

> *"That little airplane can give you a tussel the likes of which you've never had before in your life. It's fast enough. It turns on a dime. It has a reasonable zoom capability. It has very light wing loading. I've seen them split "S" from 2,000 feet. It's absolutely impossible to follow them. I've seen the MIG turn from where I had him at a disadvantage, perhaps 30 degrees angle off about a mile and a half out, maybe two, trying to get a missile shot at him, and make a firing pass at me when I was doing .9 Mach and closing. Their turn radius has to be seen to be believed. It's incredible."*

MIG-21 Fishbed

The MIG-21, besides the cockpit visibility limitation, has maneuvering problems at all altitudes when the airspeed is below 215 KIAS and above 510 KIAS. At low speeds, the aircraft may become uncontrollable, and longitudinal stick forces become extremely heavy at high speeds. The Fishbed, with a climbing spiral, zoom capability, can accelerate quickly from low and medium airspeeds because of its big thrust to weight ratio. During an engagement, forcing a MIG-21 to lower altitudes degrades its performance. [5]

This jet fighter is limited to 595 KTs at sea level. For comparison, airspeeds of more than 700 KCAS are not uncommon for the F-105. The latter has a capability of sustaining higher indicated airspeed at low levels than any aircraft in SEA. [6] An F-105 pilot commented about speed comparisons: [7]

> *"The basic comparison I would like to make is the handling capability at extremely high airspeeds within our maneuverable range of 10,000 down to 5,000 feet. With the airspeeds that we are capable of generating and the airspeeds that they are limited to as far as the handling characteristics of the aircraft, puts us in such an extremely good advantage that*

there is no comparison.

"Neither aircraft can, approaching our max airspeed, stay with the F-105. If we want to disengage, we can disengage. As you get into higher altitudes the F-105, with its high wing loading compared to the MIG-17 and MIG-21, cannot turn with them. We can still put the nose down and disengage."

Aircraft Weapons

The Soviet aircraft carry larger caliber guns, but USAF equipment is superior because of the very high accuracy, high rate of fire, and number of rounds carried. U.S. guns deliver two-to-five times the total energy (kinetic plus explosive) per second than the guns on the Fishbed C and the U.S. aircraft also carry more missiles. 8/

Vulnerability

When comparing weapons systems, vulnerability of the aircraft is an important consideration. The MIG-21 has an advantage over the F-105 and, to a lesser degree, the F-4 for combat survivability. A simple and unsophisticated hydraulic system design insures minimum damage to the MIG control system. In addition to this, a bladder type fuel tank, vented to the atmosphere, decreases effectiveness of an incendiary round or other hit. The horizontal stabilizer of this aircraft is the only flight-system requiring hydraulic boost for flight, although other control surfaces are boosted. Armor plate, lacking in U.S. aircraft, affords considerable safety to the MIG-21 pilot. 9/

CHAPTER VI

MIG FORMATIONS

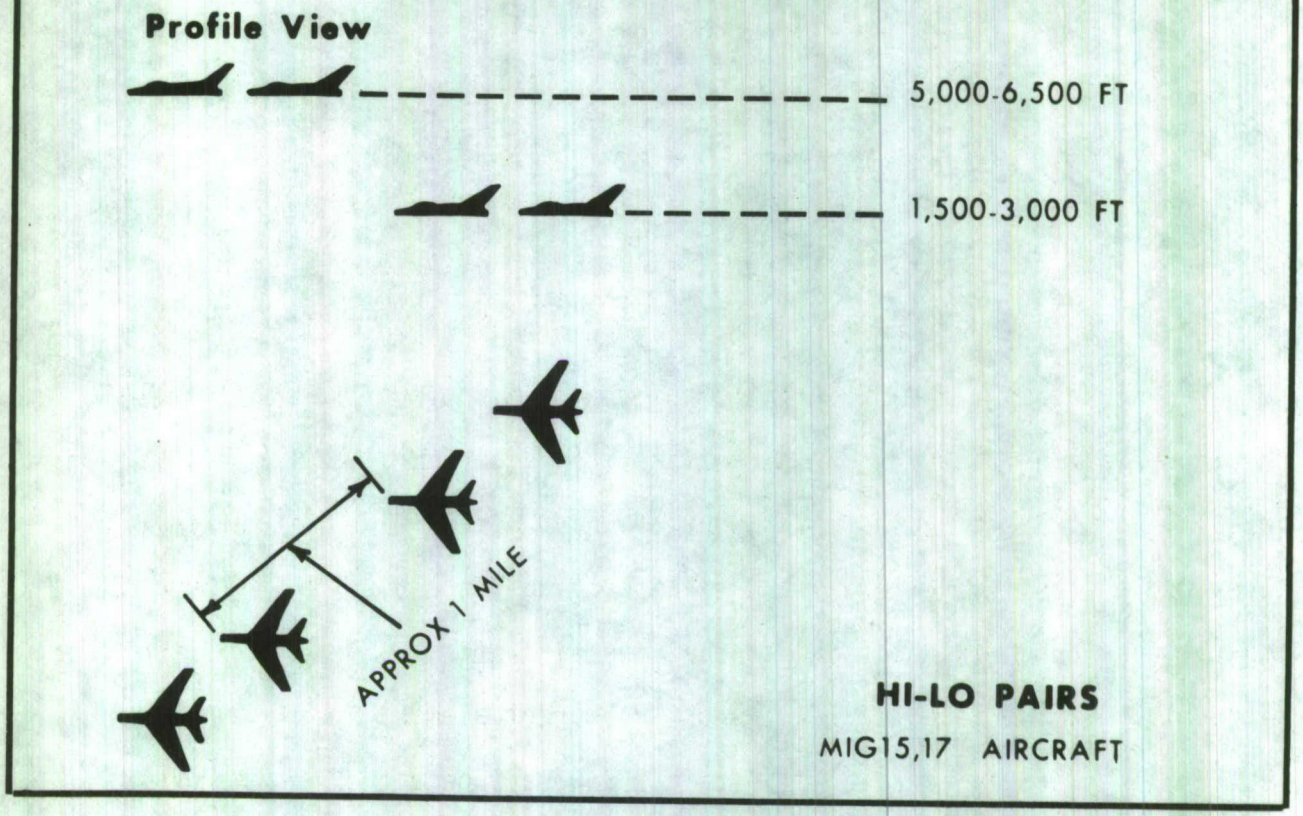
Basically there are five theoretical formations devised for an attack by MIG aircraft. The first is the High-Low Pair (Figure 5) concept of MIG-17s. Two elements of two aircraft each are arranged with the lead high, between 5,000 and 6,500 feet, somewhere in the four-to-eight o'clock sector relative to the target aircraft. The second, or low element, is usually at 1,500 to 3,000 feet, slightly behind with a mile separation from the lead element. The lead moves to a position aft and slightly above the target and launch is made against the lead aircraft. Number Two of the attacking element takes Number Two of the target element. The low pair position themselves to attack the target aircraft on a one for one basis as the evasive maneuver begins. 1/

To illustrate use of this first formation, the following encounter, occurred just after an F-105 bomb run in which the Number Three man, with his wing man, Number Four, had rolled in behind a MIG-17 pursuing Lead and Two: 2/

> *"I called flight lead and said the MIG had broken off his tail and he could slow down. At that moment a MIG dropped in behind me. Now again this coincides with published MIG tactics. They like to keep one or two aircraft at a medium altitude and another element at an extremely low altitude but within sight of the high element. I'm sure that many of the MIG's were camouflaged this day. They put two or three right down on the deck which effectively hides them from view from an attacking airplane. An attacking aircraft will see this high element and go after them, and this low element will jump up in behind the attacking aircraft."*

SECRET

MIG FORMATIONS



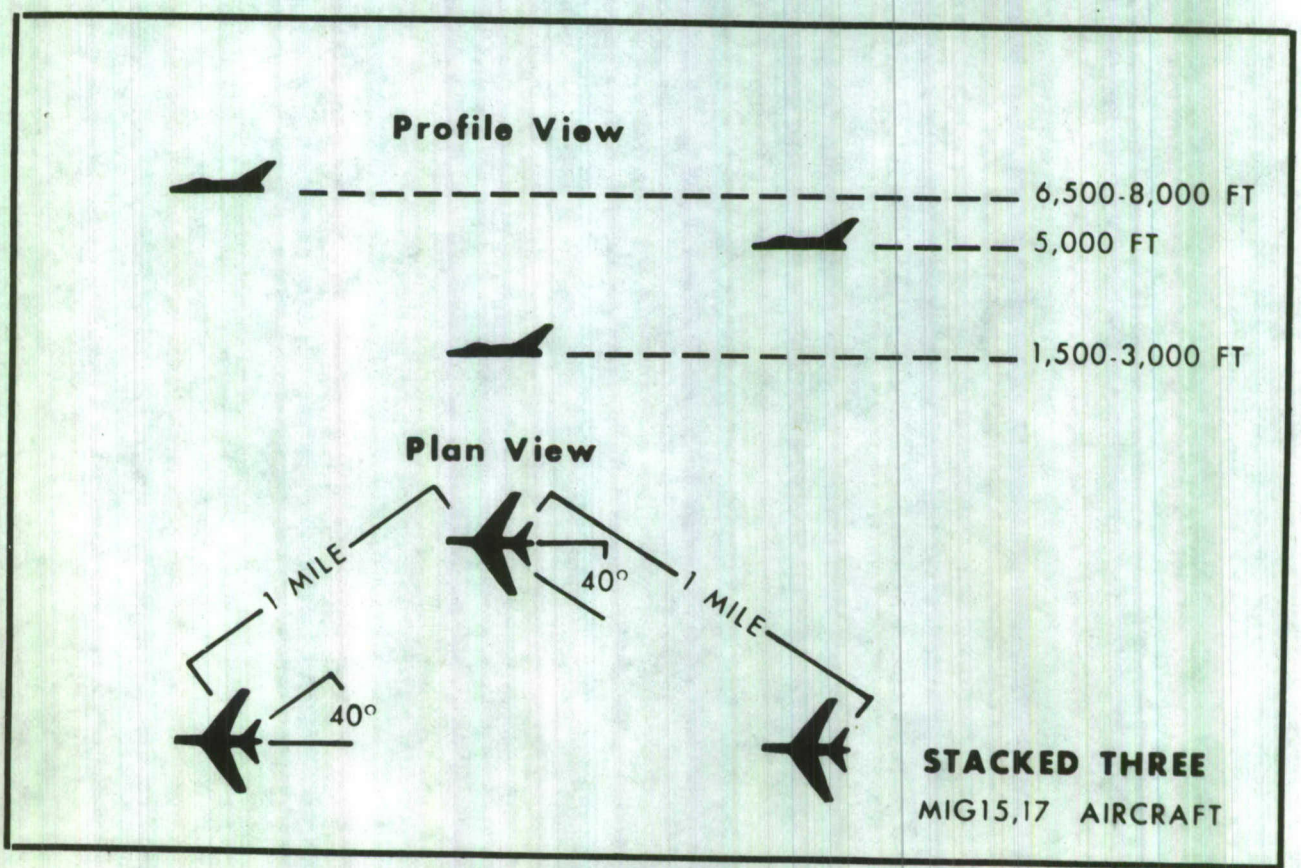


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FIGURE 5

[redacted]

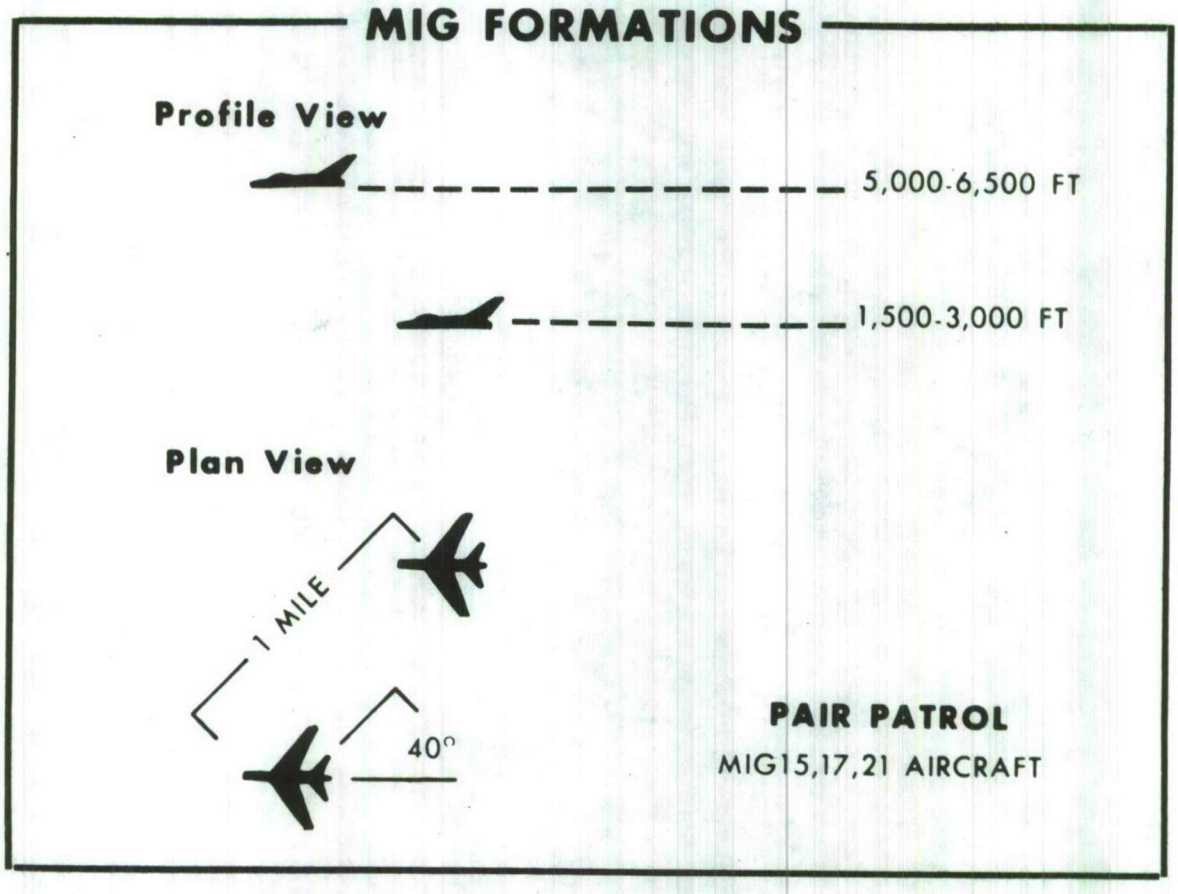


FIGURE 5A

[redacted]

Later that same day this tactics was used again: [3]

> *"We reformed in our defensive flight formation. Immediately the flight leader observed a MIG and started off after him. No sooner had he done that than a MIG came up from below me and latched onto number one and two men, further varifying this high-low element concept, or single aircraft high and low."*

In the second method, a Stacked Three loose "gaggle" of aircraft may be seen. Lead, at 6,500 to 8,000 feet AGL, is followed by a Number Two echeloned approximately 40 degrees and at an altitude of 1,500 to 3,000 feet one mile from Lead. Number Three is at an intermediate altitude of 5,000 feet, aligned aft of Lead, echeloned 40 degrees and a mile from Number Two. After gaining an altitude advantage, Lead initiates the attack on the lead target aircraft. The low MIG accelerates and from his trail position, pulls up to fire, hopefully closing on the target aircraft making a descending turn. The third MIG, with visual contact of the first two established, may join in either a high or low attack or act as airborne controller. [4]

The third method is a variation of the second, differing only in the method of attack. For harassment and an attempt to gain ordnance jettison, each MIG selects a separate flight and makes a single, level, firing pass. [5]

The fourth method is a Pair Patrol. The attack is similar to the high - low concept, and both MIG-17s and MIG-21s use it. MIG-21 formations generally have only two aircraft with the wingman providing assistance for the leader. [6]

The last method is simply the Single Patrol, employing a diving or

pull-up attack from the six o'clock position. [7]

Before making an evaluation of attack tactics, it is important to observe the well-developed Ground Controlled Intercept (GCI) tactic. The GCI controllers are used not only in positioning for an attack, but also for defense of the MIG itself. [8]

GCI Capability

An adequate GCI capability covering the entire area of responsibility has been demonstrated with the deployment of BARLOCK/FLATFACE radars paired with height finders. [9] The Soviet Fighter-Interceptor Guidance System employs a van-mounted VP-1 system to coordinate the more modern Soviet radars. The system uses semi-automatic radar data processing and reporting to give interceptor control features. Information is remoted to the VP-1 facility, stored and automatically transmitted to the next higher echelon and/or GCI center. The encoded information for close interceptor control is displayed to the pilot by normal aircraft instruments or arranged about the AI scope as a series of lights. [10]

Intercept Method

Undetected vectoring to the rear hemisphere is the desired intercept method as the GCI controller scrambles and initially directs the fighters to the general target area. The Soviets consider GCI essential to the use of the MIG-21 for effective attack. Because of forward visual acquisition limitations of the canopy, the aircraft is vectored to about a 20-degree angle from the rear of the target. The GCI controller will compute a lead

distance of five to 15 NM for the pilot to initiate a turn to the tail of the target.[11] Final attack phase from the rear quadrant is governed visually by the pilot with reference to missile limitations.

From Soviet training manuals that are generally adhered to by Soviet Bloc all-weather fighters, air-to-air intercept tactics are lead pursuit attacks with some lead collision runs used as necessary. The following three tactics are used by AI and non-AI equipped fighters:[12]

1. Cross course head-on attack with approach at right angles and a turn toward a tail chase (used only if fighters' speed is much greater than the target).
2. Parallel head-on attack on a reciprocal course.
3. Rear approach.

MIG-17s cover low altitudes because of their high maneuverability and the MIG-21s cover the high altitudes. From the higher altitudes, the MIG-21 can begin an intercept from a combat air patrol position by executing a normal or slight descending turn, followed by a dive to the target altitude, or, with good weather conditions only, by performing a split "S".[13]

A missile attack is attempted first, followed by cannon fire. The attack is begun by using a normal pursuit curve starting from one NM out to the side and about 5,000 feet above the target.[14]

CHAPTER VII

FORMATION INTEGRITY

In combat operations, proper use of formations provides the essential tactical advantages of lookout capability, mutual support, and concentration of firepower. The lone aircraft is extremely vulnerable to attack by enemy aircraft. Without the mutual protection afforded by the formation, the lone aircraft poses an easy target for a low aircraft attacking from the six o'clock position.

Reflecting on past missions, an F-105 pilot suggests the loss of two, possibly three planes because of failure to maintain good flight integrity: 1/

> *"The prerequisite is flight integrity during the peak of MIG activity. We had stragglers, and I can think of two, possibly three, that were almost positive due to the fact that they were straggling behind, without the protection of the rest of the flight. They were almost definitely knocked down by MIG's.*
>
> *"You will find that when the flight is together and the force is together, there is quite a hesitancy for them to attack. They would rather sit off and pick off the stragglers."*

Since the most important principle of formation tactics is the constant maintenance of element and flight integrity, the knowledge of where to position the aircraft in relation to other flight members, and the ability to think and maneuver in the flight will insure maximum of protection for that entire force. Formations must insure the requirements of optimum maneuverability, simplicity, and adaptability to the specific mission and existing conditions. 2/

CHAPTER VIII

THE STRIKE FORCE

A major strike effort is defined as a mission fragged against a specific target which will require the establishment of three or more strike/flak suppression flights and an IRON HAND support flight. After a coordinated drop-off from the tankers, the flights join-up and proceed over the non-defended target access routes over Laos or the Gulf of Tonkin. The escort flights are joined at, or before, the two initial turning points, Channel-97 or Wei Chou Island. 1/

When entering hostile airspace, a pod formation is formed. There are basically two types used by F-105 strike flights: the tight "cell" formation by the 388th TFW, with two minutes between TOTs, and a more loose pod formation by the 355th TFW. The latter generally consists of a loose trail with one-half to one mile separation between flights and with TOTs of 30 seconds to one minute. The first provides easier navigation and target acquisition, while maintaining greater separation from AAA/AW sites. The disadvantage is the inherent limitation in maneuverability and flexibility for reaction to missile or MIG threats. The second type views the pod protection as a bonus, while flexibility of response to the MIG or SAM is kept. Basic formations are never completely set; they change with innovations in tactics and techniques. This keeps the advantage of force protection from any enemy defense. 2/

Escorts

The F-4 escorts counter any threat which might prevent the strike aircraft

from dropping the bombs on target.[3] The actual role of the F-4 has changed with changing MIG aggressiveness. After the downing of three F-105s on 30 April 1967, the F-4s became strictly a MIG CAP force, carrying no bombs.[4] These escorts were very effective in protecting the strike aircraft by flying closer to the strike elements.[5] When encounters decreased, they returned to the strike role.

Strategy of the U.S. strike force includes a MIG Screen/CAP, in which the fighters are placed between the MIG threat and the friendly force or in a tactically advantageous position. In North Vietnam, the primary threats came from Phuc Yen, Kep, and Gia Lam airfields.[6] Rules of Engagement require that the MIG CAP aircraft obtain positive Identification Friend or Foe (IFF) before missile launch.[7]

The 388th TFW Operations Instruction offers these precepts in response to a MIG threat: the escort flight of F-4s will first deploy to engage the attacking MIGs. If the MIGs are in range and clear of the strike force, air-to-air missiles may be launched. If the MIGs press the attack, the escort flight will engage.[8] Once the F-4 flight has engaged or has been separated for any reason, the strike force will assume their own escort responsibility. This may be accomplished in two ways. The strike force may move in a diamond formation, with Number Four flight assuming escort responsibilities. This F-105 escort flight still has the primary mission of bombing the target, but it is authorized to jettison ordnance and then engage for the purpose of aiding the rest of the force to hit the target. The escort first makes a shallow turn into the attack and then jettisons ordnance and engages if the

MIGs have not yet been deterred. [9]

The second option keeps the force in the box with the two rearmost flights becoming the escorts. The flight on the side of the attack goes through the same procedure as the Number Four flight in the diamond formation. [10]

The question of ordnance jettison is strictly a judgment by the flight leader. He interprets the MIG threat, based on knowledge of his own aircraft performance, and also the MIG's performance and weapons system capabilities. If ordnance is dropped needlessly, the mission is negated. If it is held too long, the strike flight is jeopardized. [11]

Speaking for the 355th TFW of F-105s at Takhli, Thailand, Maj. Ted Tolman says that only in one instance did the whole force have to jettison ordnance. Two F-105s had been shot down and the entire force was diverted into a RESCAP role. [12]

> *"This was a rather unique situation and the MIG was responsible...Prior to this time I don't know of any case where the MIG attacks completely thwarted an entire strike force of ours. I can't speak for Korat or any of the other wings. I don't think there ever has been a case where anymore than an element or a flight has not gotten to the target."*

The ingress to target, with the flights tight and offering mutual visual coverage, is the period of greatest protection. The flights, moving at a speed that can outdistance the MIG, are grouped and organized against attack.

The most vulnerable part of the mission is during and right after the

bomb run, when confusion and often separation results.[13] Attention is diverted to target acquisition and jinking to avoid ground fire. The MIGs haven't pressed attacks too frequently during this time. In an F-105 engagement on 30 April, MIG-17s were encountered.[14]

> *"Rattler flight was notified by number Four of three MIG-17s at three o'clock, one mile and level. MIGs appeared to be in a slight left orbit. MIGs continued left turn and began climbing with Rattler flight into pop-up maneuver. MIGs reversed direction to the right and began firing from approximately 1,500 feet. Rattler was accelerating and the MIGs fell behind."*

The importance of flight and element integrity has been stressed. This is especially true for egress, when a lone straggler can be jumped from behind quite easily.[15] Use of the afterburner during recovery from the target is recommended, since the fuel penalty is not considered significant. Mach 1 speeds cannot be matched by the MIG-17, and the MIG-21 must be in an optimum position to complete an attack.[16]

CHAPTER IX

MIG OFFENSE AND DEFENSE

Offensively, the MIGs perform best using hit and run tactics with a high speed missile or gun firing pass, hoping to get a strike flight to jettison ordnance. [1] During the period of high MIG aggressiveness, this unsuccessful attempt took place: [2]

> *"On the 4th of May we were going down Thud Ridge and I spotted two MIG-21s slicing into the F-105 force from our left, coming in at about seven o'clock to the F-105s and going like bats out of hell. Another pair was up the stream going on the next to the last flight. They broke, saw the MIGs, jettisoned their ordnance, and got out of there, which is a smart thing to do.*
>
> *"In the meantime I attacked the two rear-most MIG-21s which were pressing in on the nearmost F-105 flight. One of them spotted us and immediately dove to the deck. I didn't see him again. The other one turned and twisted, we maneuvered, turned and twisted and I finally let him have it with a Sidewinder. After some wild gyrations he crashed about 100 yards south of the runway at Phuc Yen."*

The downed MIG accomplished one of the objectives of air defense, the strike force dropped their ordnance, negating the possibility of mission accomplishment.

The MIGs have orbit points around Hanoi but these are far from set paths. They possibly are on alert, then scramble to the area where the U.S. strike force is going or is anticipated. [3] Attacks occur around the clock, and this one at the six o'clock position is the result of coordination with early warning radars: [4]

"They preferred to come in low from a six o'clock position. They started their attack from, more than likely, a forward three o'clock position, gaining speed and making a turn that would place them in our six o'clock position and low. I say low because some of the MIG-21s were obviously using the Atoll infrared homing missile. The results of this type of tactics were partially effective in that they caused the striking aircraft or flights several times to jettison ordnance and thereby, not get it to the target."

Although MIG activity may be expected anytime during the mission, a few areas along the commonly used ingress and egress routes seem to be favored. From the general area around Yen Bai, attacks are initiated from the north along the commonly used strike route from the turning point, Channel 97. For the southern route, attacks have been staged from the Hoa Binh area as well as in the valley, 17 miles south of there which contains Route 12.[5] Gulf of Tonkin MIGs attack along the east-west mountain ridge north of Haiphong called MIG or Phantom Ridge.[6]

After GCI vectoring to the strike force, radars continue to provide information to the MIG pilots about the strike and escort force. If the escorts are engaged, the information is relayed to the MIGs as to which elements of the strike force are now vulnerable. Recently, MIG pilots have indicated a willingness to engage for longer periods of time--reflecting an increase in pilot confidence.[7]

Gunfire

Gunfire from the MIG aircraft has been relatively ineffective. The MIGs have lost opportunities for kills because of their poor shooting ability, combined with technical problems of a poor optical, lead-computing

gunsight.[8] Colonel Olds commented: *"The one thing I think they lacked, thank God, is the ability to shoot. I've seen as many MIGs behind me shooting as I've seen in front of me being shot at."*[9]

Compensating for their shooting abilities, the NVNAF can coordinate their attacks well. On 12 May 1967, F-105s encountered a flight of five MIG-17s. Four of these crossed to the left in front of the flight at a 45-degree angle and made a turn to come up behind the F-105s. One lone MIG-17, at the same time made a 90-degree intercept from the right. The attack was unsuccessful, however, and the F-105s outran the MIGs.[10] These coordinated attacks have a tendency to fall apart once an engagement begins. More often than not lone MIGs will be scattered when the pressure of a counterattack by U.S. planes impacts.[11]

Single MIGs become the prey of an attacking U.S. aircraft, and the consequences of violating the principal of element integrity apply to MIG pilots as well. This one lost track of his rear quadrant:[12]

> *"MIG was in a right, level turn heading approximately 330 degrees chasing an F-105. MIG apparently never saw Atlanta flight. Atlanta One approached the MIG from his four o'clock position and at approximately one and a half miles, 30 degrees off, fired one AIM-9 missile. Missile did not guide. Atlanta One continued in and at 10 degrees off, 1,500 feet, began firing 20MM. Continued firing to 700 feet range at which time the MIG burst into a large ball of flames."*

Defensive Tactics

Defense tactics make use of the capabilities of a particular plan to counter the weapons system of an attacking plane. For the MIG-21 in a

surplus speed situation, a climbing turn is recommended, because of the maneuverability and climbing advantage. If low speed is the case, the MIG-21 dives in a high G turn. Because their aircraft has lower wing loading than U.S. models, a much tighter turn may be performed. 13/

MIG-17s defend themselves best by turning into the attacker and taking advantage of their extremely short-turn radius. It can out-turn any U.S. aircraft, often taking the offensive, with a shot at the former attacker or his wingman going wide. 14/

MIG-17s will sometimes dive to the deck to avoid the missile threat. On 19 April, Flapper flight on egress was engaged with a MIG-17. Flapper Three had just achieved a full system radar lock and was preparing to launch an AIM-7 when an F-105, firing 20-mm, broke into the attack. The MIG, under attack from two aircraft, immediately broke right and dove from 2,000 feet to 200 feet AGL. With radar lock continuing to break, an AIM-7 was still launched as minimum range was approached. After a few high-speed yo-yos, a boresight lock-on was obtained by Flapper Three following the MIG through some turn reversals. A second, and later, a third missile were launched but they impacted on the ground, resulting in no damage to the MIG. The use of low altitude and hard maneuvers saved the aircraft from a missile-armed F-4C. 15/

The Wagon Wheel

One very significant tactic used by the MIG-17 is the large Wagon Wheel or Lufberry Circle, composed of two, three, and sometimes four aircraft. The wheel formation, a very wide circle, allows coverage of everyone's six

o'clock position, and may be used in two ways. The circle can tighten up, keeping the faster-moving, heavier U.S. aircraft from getting into the turn or, each time a USAF plane engages one of the groups, a MIG from across the circle can go full power and pull across the circle, to be in a firing position on the attacking plane. 16/

One flight of F-4s, arriving at the scene after an engagement had begun, spotted two controlling aircraft sitting high to each side of the circle, directing the fight that was going on. 17/ Countertactics were soon developed and to combat these, the MIGs anchored half of the circle over Kep airfield, where the flak negated USAF countertactics. 18/ This twist of a previously used tactic occurred at the end of May as MIG activity trailed off.

MIG Activity Changes

The following summary of changes in MIG activity illustrates the significance of the period from January to June for the air-to-air war. With the completion of Hoa Lac airfield, the MIG-17 and MIG-21 force were now operating out of six airfields permitting better dispersal of aircraft and facilitating the recovery of aircraft in the Hanoi area. 19/

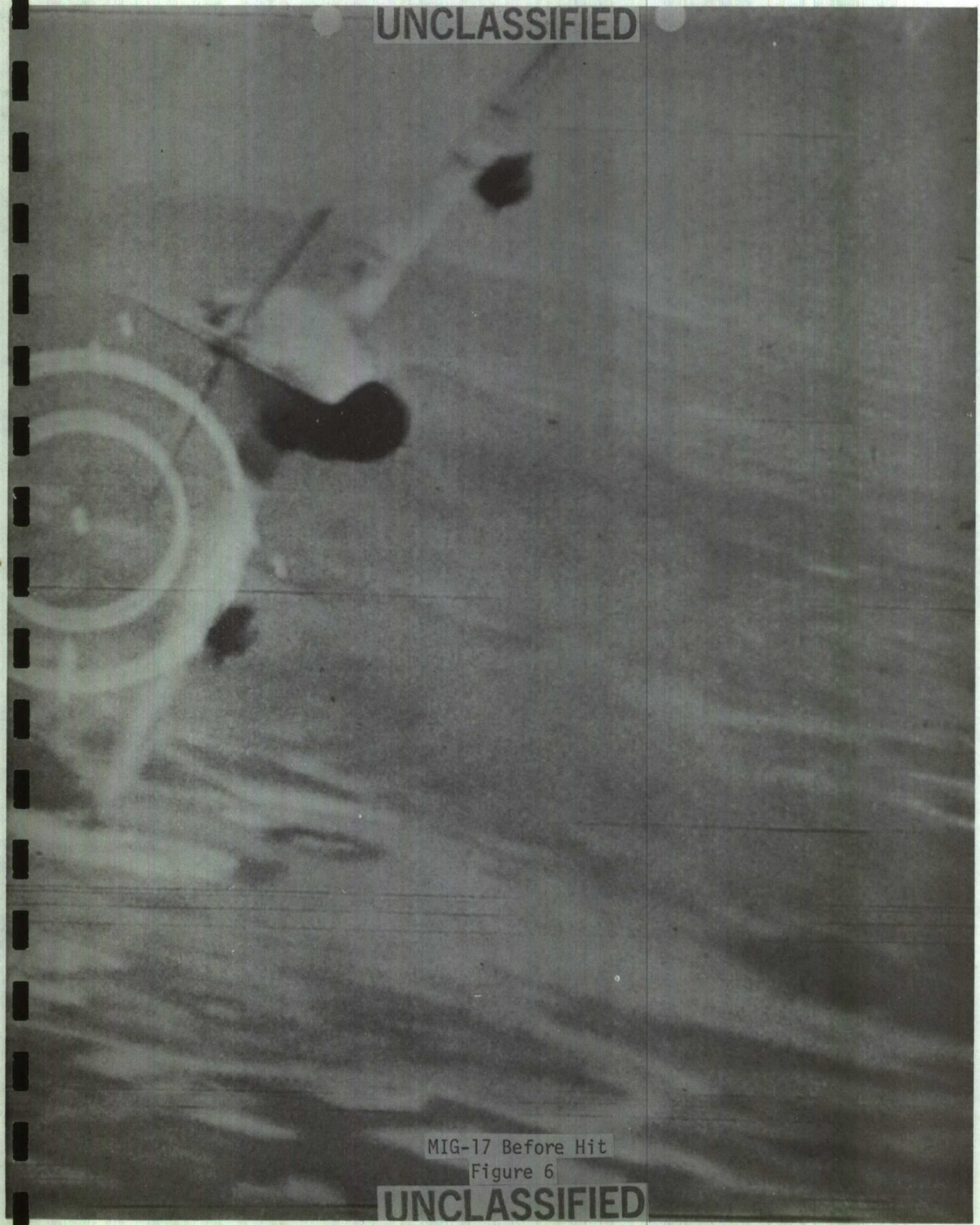
Twenty-seven encounters in January resulted in nine MIG kills, with no U.S. losses. 20/ The VNAF stunned by the loss of seven MIG-21s on 2 January, entered another training phase. Although MIGs were sighted in their previous operating area, aggressive attempts to engage did not occur. Intelligence reports forecast a more aggressive role once this training period was finished. 21/

Due to consistently poor weather, MIG activity in February was curtailed. No losses of MIG or USAF aircraft occurred in the five encounters. A new development was noted, however, in the use of airborne intercept (AI) equipped MIGs. Photography showed MIG-21Ds and Fs and MIG-17Ds, equipped with faster search and conical scan tracking band radars. RHAW equipment reported an increase in X-band strobing. 22/

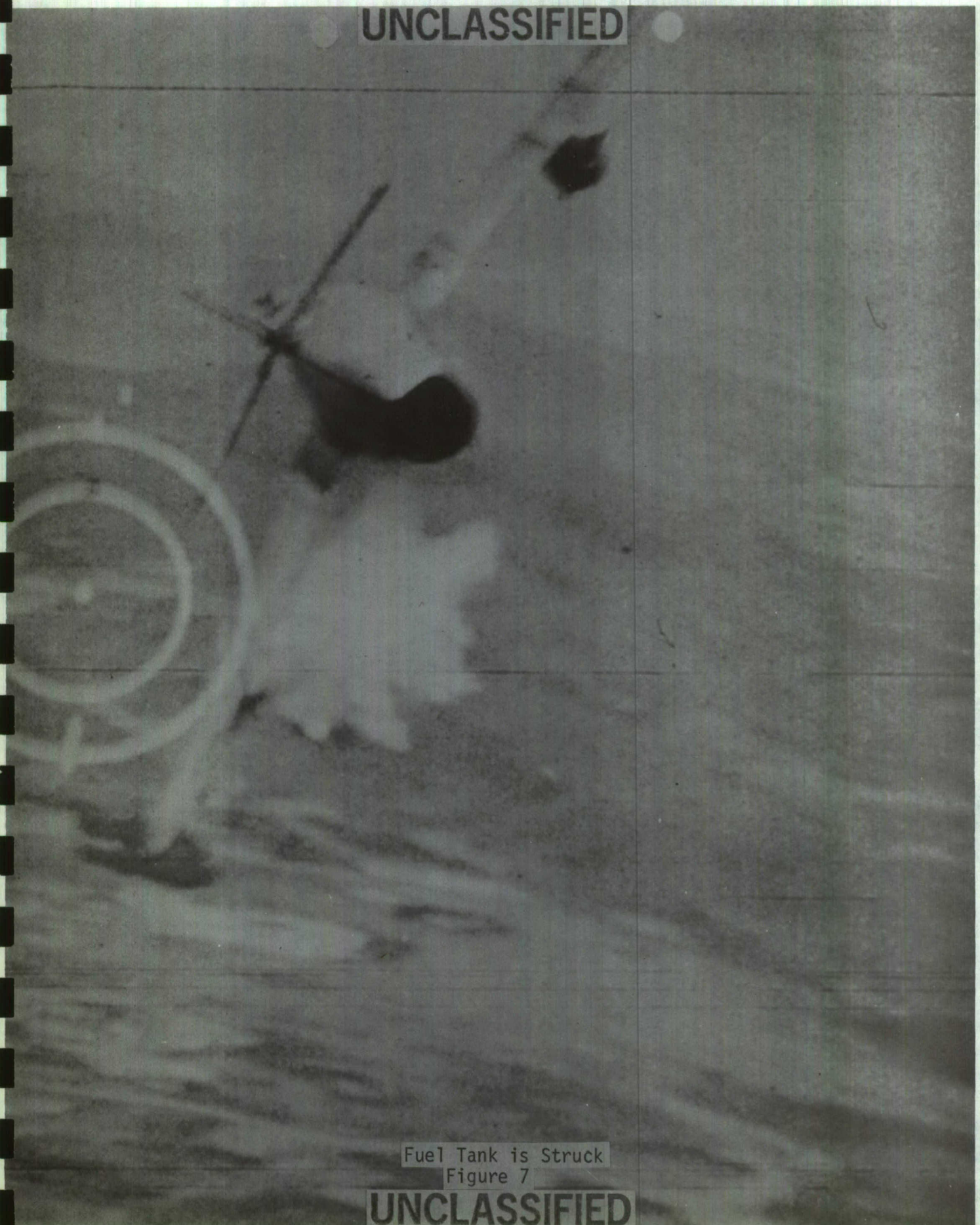
Twelve encounters led to two MIGs downed and no USAF losses in March. MIGs, no longer rising in force, were capping their own bases in one or two four-plane flights. A few MIG-21s, armed with AAMs, had tried a single aircraft attack on U.S. strike flights. MIG-17s flew generally between 3,000 and 9,000 feet, while the MIG-21s were between 10,000 and 21,000 feet. 23/ To obtain the highest performance characteristics and capabilities from MIG-17s, they should be at the lower altitudes and the MIG-21s at the higher ones. 24/

April brought a weather improvement and a very great increase in MIG activity. During the week of 20 April to 26 April 1967, 96 enemy aircraft were seen by strike aircraft in Route Package VI. MIG-21s were engaged seven times, while MIG-17s were involved in 17 engagements. 25/

JCS' approval for strikes on the Kep and Hoa Lac airfields came on 23 April, and strike attacks soon left nine MIGs, with three possibles, destroyed on the ground. Extremely vigorous MIG reaction to the bombings and increased sorties into NVN, resulted in the loss of nine USAF/USN aircraft from 19 April to 30 April. Engaging in day fighting with cannon, before and at



MIG-17 Before Hit
Figure 6



Fuel Tank is Struck
Figure 7

MIG Explodes
Figure 8

the target, MIG-17s stayed below 9,000 feet in orbital patterns. The use of MIG-21s for poststrike AAM pursuit preserved that force, but at the expense of the MIG-17s.[26]

The MIG activity reached a peak during the latter half of April and the first half of May. In May, 26 MIGs were downed, while two F-4Cs were the only U.S. planes lost. Thirty-five encounters were recorded during the month, but aggressiveness trailed off at the end. Although many were sighted, few MIGs specifically challenged U.S. penetrations into the north. Even though MIG aggressiveness waned, the Wagon Wheel or Lufberry Circle tactic was used in late May. The "G" loads and constant changes in altitude and spacing successfully frustrated U.S. pilots until countertactics were worked out and used.[27]

On 30 April, MIGs shot down two F-105 aircraft on their way to the target and a third was lost when the F-105 flight aborted its mission to provide RESCAP. This resulted in employing the F-4 in a pure MIG CAP role.[28] An F-4 escort flight was sandwiched behind the lead flight of F-105s, with another flight of F-4s at about the same interval of 1/2 to 3/4 mile behind.[29]

No MIG encounters were recorded from 6-30 June.[30] On 5 June, three MIGs were shot down by F-4Cs. The MIG remained, however, a threat by maintaining the capability to challenge at will or avoid combat.[31]

Superior facilities and runways at Phuc Yen probably influenced retention of MIG-21s in that area for the first four months of 1967. In February, MIG-17s were reluctant to engage F-4s, and the NVNAF used the MIG-21 whenever possible

against them. The MIG-21 was positioned at Phuc Yen to intercept the U.S. strike flights which came to Hanoi from the northwest. 32/ The Tam Dao Mountain Range, called Thud Ridge (after the F-105s), extends northwest from Hanoi. These mountains provide terrain masking for egressing strike flights. Kep and Hanoi/Gia Lam appear to have a good portion of the MIG-17s based there. 33/

CHAPTER X

U.S. WEAPONS EVALUATION

The cardinal rules of air-to-air tactics have remained unchanged since the plane was first used as a military vehicle. Aggressiveness, good training and preparation, a plan of action, formation integrity, and the inviolate requirement for a pair of fighters are all well understood by fighter pilots.[1] Good aviators are not necessarily good fighter pilots, because they have not been exposed to the fighter environment. Training opportunities are used by many wings whenever possible to indoctrinate new pilots to maneuvers and the environment they will face. Element integrity is of utmost importance.[2]

According to Colonel Olds:[3]

> *"Unfortunately, you can't train a man in the United States for what he has to do in combat. It's difficult to simulate air-to-air combat when you put two aircraft of equal characteristics, equal thrust, equal wing loading, equal pilot training, against each other. You usually wind up in a rat race. The thing degenerates into an exhibition of all the things you should not do in air-to-air combat. People try to out-turn each other and start flying slower and slower and get lower and lower. That's the best way I know to get knocked down."*

Utilizing flying time and fuel on board give the pilots, under practice conditions, a familiarization with the basic rules and maneuvers that will be needed for combat with the MIG. Experienced flight leaders must analyze many variables upon a MIG encounter, including:[4]

- MIG flight positioning and flight path.
- Present fuel state which determines whether or not the flight can engage.
- The type of MIG and the best position for attack.
- Airspeed and/or altitude advantages.
- Defensive environment of the area AW, AAA or SAM.
- Aircraft flight and drag limitation. Along with these weapons capabilities and reliabilities, enter the decision process.

The requirement for visual identification of targets before weapons release provides the enemy an opportunity to discover an attacker. Combined with this, the ground radar protection for the MIG force warns of attacking U.S. planes, turning the battle into maneuvers for an advantageous firing position. The U.S. air-to-air missiles used in SEA, the AIM-9B Sidewinder and the AIM-7E Sparrow, were designed for non-maneuvering systems (Appendix VIII) in a defensive rather than an offensive environment. Their effectiveness is degraded during the maneuvering battle of air-to-air conflict. 5/

Weapons Evaluation

The AIM-4D Falcon missile, used only to a limited degree, has been very ineffective and has only led to pilot frustration because of the missile failures. 6/ An evaluation of ordnance expenditure for the period of 23 April to 8 July 1967, including the peak in MIG activity, showed that out of ten missiles--all fired by the F-4--eight were misses and two did not guide. No hits or probable hits were recorded, although all launches were within the launch envelope. 7/

Sidewinder

The infrared homing Sidewinder AIM-9B is a relatively easy weapon to fire. The 1,300 to 1,500 fragments produced at detonation, travel at 6,000 feet per second and can penetrate one inch of aluminum and 3/8 inches of steel at 30 feet. It has proven to be an effective missile when launch conditions are met, but obtaining these launch conditions in a maneuvering environment presents problems. 8/

The design limitations affecting usage and reliability are:

- IR discrimination.
- Lambda
- Gs
- Range

The missile does not effectively distinguish between clouds, water, the sun, or any IR source. Lambda, the look angle of the gyro seeker, is limited to 25 degrees, either side of the longitudinal axis. A maneuvering target, by turning, attempts to rotate its lethal cone away from the launch aircraft, forcing the missile to exceed its Lambda limits. The missile not only slows down in the turn, but must aim farther in front of the target to make the intercept, and once the Lambda limit is exceeded, it goes ballistic. In addition to these problems, the launching aircraft must not exceed a two-G, maneuver, because the line of sight rotation rate will exceed the tracking rate of the gyro seeker and the missile will go ballistic. The launch range minimum is 3,000 feet. 9/ Maneuvering to meet launch

parameters depends upon the skill and knowledge of the pilot in getting optimum performance from the weapons system. 10/

The Sparrow

The AIM-7E Sparrow missile is an all-weather missile which guides on the radar beam of the launching aircraft. A positive closure rate is desired for launch. The missile has been effective when pulling up to five Gs at launch, but the probability of a single weapon guiding and killing decreases. In addition to this, the requirement for visual ID warrants firing in ripples of two to insure some degree of success. 11/

Because this missile is a beam rider, the aircraft must maintain a radar lock-on for the entire flight of the missile, a difficult task in maneuvering flight. The missile goes ballistic with a break of the lock-on, and it may also transfer the lock to the top of a mountain because of ground-return cluttering the scope.

On 20 May, the third AIM-7E fired by Lt. Col. Robert Titus finally impacted on a MIG-21 resulting in a confirmed kill. 12/

> *"As they rolled out, the aircraft commander of Elgin 3 spotted still another MIG-21 shimmering in the sunlight, attempting to position himself at the six o'clock position of the strike flight.*
>
> *"While maintaining full system lock-on, Elgin 3 fired one AIM-7 which immediately broke right and was not observed again. Elgin 3 then went interlocks out and fired another AIM-7 while at 3 NM range. The MIG-21 was still in a hard diving turn. This Sparrow performed exactly as did the first.*
>
> *"Still closing slowly and maintaining position on the*

MIG-21C, Elgin 3 with Interlocks out fired another AIM-7 which tracked beautifully and impacted directly on the left wing root while the MIG was presenting a plain view to Elgin three."

Missile Effectiveness

In a study made of the relative effectiveness of weapons employed on U.S. aircraft for air-to-air combat (Appendix IX), 35 percent of the AIM-7s and 26 percent of the AIM-9s were considered launched outside of permissible parameters.[13/] In observing the percentage of hits recorded, the need for a more capable air-to-air missile system becomes obvious. There were only 11.1 percent recorded hits, with 2.8 percent designated probables, of the AIM-7s fired during the period of 23 April to 8 July 1967. For the slightly more effective AIM-9, there were 18.6 percent hits recorded, of which 1.7 percent were probables.[14/] These statistics indicate that the maneuvering environment of air-to-air combat presents many problems to the fighter pilot who is dependent upon the missile as his only weapon.

M-61 and SUU-16 Cannon

The F-105 aircraft carries the M-61 gun, which meets the need of a fighter aircraft weapons system for close-in air-to-air combat, as it performs well throughout the flight envelope.[15/] The F-4C was not designed with an internal cannon, and was solely dependent upon air-to-air missiles until the arrival of the externally mounted SUU-16 gun pod.[16/] Prior to getting the gun pod, a pilot, in maneuvering to achieve missile firing parameters, would often find himself too close to the MIG, when only a gun could be used.[17/] On other occasions, the MIG would escape by heading for the deck where

ground clutter obviated the missile capability to track. In this circumstance, a gun could have been employed to bring down the MIG. 18/

The modification of the F-4C to carry the SUU-16 gun pod on the center line results in a significant improvement in air-to-air capability. Fuel requirements and the need of the ECM pod prompted modification, which led to placement of the ECM pod inboard and two fuel tanks outboard. This still provided space for a Sidewinder/Sparrow mix to give tertiary capability to the F-4C. 19/

On 22 May, Colonel Titus downed his second MIG of the day by chasing a MIG-21 into a twisting, turning, hard-maneuvering dive from 25,000 feet to about 2,000 feet. No radar lock-on could be made, but use of the SUU-16 gun pod resulted in a kill. 20/

As stated by another fighter pilot: *"Eventually we are going to get the E model airplanes with the internal gun. That's the answer, obviously. I think the Air Force has learned its lesson. We will never build another fighter without an internal gun. At least I hope we don't."* 21/

CHAPTER XI

COUNTERING THE MIG

The key to evasion is early detection of the enemy. When entering the area of strong enemy air defenses, a strike flight, F-4 or F-105, increases the speed to approximately 520-540 KCAS. While Lead looks for the target, Numbers Two, Three, and Four are concentrating on the SAM or MIG threat. 1/

When an enemy attack is discovered, a turn into the enemy with acceleration may allow a head-on gun attack with a high speed overshoot, placing the enemy in an unfavorable position for reattack. The big advantage of the power in the F-105 and F-4 is the ability to disengage almost at will. By exploiting the speed capability during an encounter, pilots can overcome the basic maneuvering capability limitation of U.S. aircraft. 2/ To separate from a MIG-17, U.S. pilots usually utilize afterburner for a zoom climb. 3/

On ingress to the target on 20 May 1967, Plymouth flight observed 2 MIG-17s approaching from the 10 o'clock position, and attempting to make a firing pass. Engaging the afterburner and accelerating left the MIGs far enough behind so that the bomb run could still be made. 4/

The best acceleration is achieved by "humping" the aircraft, a zero G pushover, with the afterburner engaged. Abrupt jinking presents a difficult tracking problem and effectively breaks a MIG attack. 5/ The MIG attack has affected strike operations in primarily three ways: 6/

1. Construction of formation. Formations provide rearward

lookout capability when tightened up, but sacrifice offensive or maneuverable positions.

2. Jettison of ordnance in anticipation of engagement. The strike aircraft are still exposed to NVN defenses while the target has not been hit. This requires more aircraft to be sent against the same target.

3. Preoccupation of strike pilots. The threat produces difficulty in target acquisition and possibly in ordnance delivery.

Construction of the formation in the optimum defensive arrangement increases safety of the strike force. A sharp lookout for enemy attacks and employment of evasive maneuvers, making use of the speed capability, will decrease the amount of ordnance jettisoned. These formation tactics insure both good target acquisition and force protection.

In April and May 1967, F-105 strike forces tasked the first flight off the target as a MIG CAP. This provided an additional defense for the other egressing flights.[7] Both F-4 and F-105 pilots feel that a tightened F-105 strike formation, with the F-4 escort mixed in, has proven to be the most effective defense.[8]

Offense Against the Wheel

Techniques of offense and defense change in a see-saw manner as each opponent tries to develop the advantage. The Wagon Wheel - Lufberry Circle defense by MIG-17s was one such technique. The theory, timing, and radio procedures of an encounter tactic, fighting as coordinated pairs, were developed by one F-4 Wing after learning the circle could not be penetrated with a mass, eight-plane attack.[9]

The circle was next seen anchored halfway over Kep Airfield, a concentrated area of AAA/AW. On 5 June, tactic changes paid off with the downing of two MIG-17s. The coordination of one element engaging the MIGs, while the other element gains separation and readies for reattack, completely frustrated the MIG pilots. One element calls inbound and the other, with the excess power of the F-4, disengages, opening the MIGs to a missile attack, or a gun-firing pass, if the pod is being carried. Coordinated attacks by elements, pairs of aircraft, set the pace for this tactic.

CHAPTER XII

SUMMARY

USAF aircraft achieved a 5.4 to one kill ratio over the MIG force, since the beginning of Southeast Asia hostilities. Operation BOLO, conducted in January, resulted in the destruction of 44 percent of North Vietnam's first line fighter aircraft and accounted for 21 percent of all USAF aerial kills in the NVN conflict.[1/] By the end of June 1967, the overall U.S. kill ratio was five to one.[2/]

After 1 January 1967, the NVNAF displayed an aggressive commitment of a large fighting force. Their state of training was obviously further advanced than before. After suffering 33 aircraft losses between April and June 1967, however, they appear to be undergoing a retraining program.[3/] Their GCT sites keep the MIGs well clear of U.S. strike forces.

NVN air defenses were strengthened as the enemy upgraded the quality of their aircraft, added radars to their inventory, and increased their antiaircraft artillery during the first half of 1967. A continuing steady increase in strength and proficiency in MIG and SAM forces in North Vietnam was foreseen.[4/] Aware of this threat, the U.S. pilots remain poised for the next round of air-to-air engagements over North Vietnam.

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APPENDIX I

USAF - MIG SHOOTDOWN RECORD

DATE 1967	ROUTE PACKAGE	AIRCRAFT (U.S. - MIG)	ACTION	CALL SIGN
2 Jan	6A	4 F-4C 4 MIG-21	3 MIG-21 Kill	Olds
2 Jan	6A	4 F-4C 7 MIG-21	3 MIG-21 Kill	Rambler
2 Jan	6A	4 F-4C 3 MIG-21	1 MIG-21 Kill	Ford
6 Jan	6A	2 F-4C 4 MIG-21	2 MIG-21 Kill	Crab
10 Mar	6A	2 F-105 4 MIG-17	1 MIG-17 Kill	Kangaroo
26 Mar	6A	2 F-105 4 MIG-17	1 MIG-17 Kill	Leech
19 Apr	6B	1 F-105 2 MIG-17	1 MIG-17 Kill	Kingfish
23 Apr	6A	3 F-4C 2 MIG-21	1 MIG-21 Kill	Chicago
26 Apr	6A	4 F-4C 8 MIG-21	1 MIG-21 Kill	Cactus
28 Apr	6A	4 F-105 3 MIG-17	1 MIG-17 Kill	Spitfire
28 Apr	6A	4 F-105 1 MIG-17	1 MIG-17 Kill	Atlanta
28 Apr	6A	2 F-105 1 MIG-21	1 F-105 Kill	Lightening
30 Apr	5	4 F-105 2 MIG-21	1 F-105 Kill	Tomahawk
30 Apr	5	2 F-105 2 MIG-21	1 F-105 Kill	Carbine
30 Apr	6A	4 F-105 3 MIG-17	1 MIG-17 Kill	Rattler
1 May	6B	4 F-4C 8 MIG-17	2 MIG-17 Kill	Stinger
4 May	6A	4 F-4C 2 MIG-21	1 MIG-21 Kill	Flamingo
12 May	6A	3 F-4C 6 MIG-17	1 F-4C Kill	Dagger
12 May	6A	4 F-105 4 MIG-17	1 MIG-17 Kill	Crossbow
13 May	6A	4 F-105 1 MIG-17	1 MIG-17 Kill	Tamale
13 May	6A	4 F-105 2 MIG-17	2 MIG-17 Kill	Random
13 May	6A	4 F-4C 7 MIG-17	2 MIG-17 Kill	Harpoon
13 May	6A	4 F-105 3 MIG-17	2 MIG-17 Kill	Chevrolet
14 May	5	2 F-4C 8 MIG-17	2 MIG-17 Kill	Speedo
14 May	6A	4 F-4C 6 MIG-17	1 MIG-17 Kill	Elgin
20 May	6A	4 F-4C 6 MIG-17	1 MIG-17 Kill	Tampa
20 May	6A	4 F-4C 8 MIG-17	1 MIG-17 Kill	Ballot
20 May	6A	4 F-4C 8 MIG-17	1 F-4C Kill	Tampa
20 May	6A	3 F-4C 2 MIG-17	2 MIG-17 Kill	Tampa
20 May	6A	4 F-4C 4 MIG-21	2 MIG-21 Kill	Elgin
22 May	6A	4 F-4C 2 MIG-21	2 MIG-21 Kill	Wandes
3 Jun	6A	4 F-105 3 MIG-17	2 MIG-17 Kill	Hambone
5 Jun	6A	4 F-4C 4 MIG-17	1 MIG-17 Kill	Oakland
5 Jun	6A	4 F-4C 8 MIG-17	1 MIG-17 Kill	Chicago
5 Jun	6A	4 F-4C 8 MIG-17	1 MIG-17 Kill	Drill

APPENDIX II

MIG WEAPONS CAPABILITY

TYPE	CANNON	AIR-TO-AIR ROCKETS	MISSILES
MIG-17A	1 N-37 2 NR-23	Yes	No
MIG-17B	1 N-37 2 NR-23	Yes	No
MIG-17C	1 N-37 2 NR-23	Yes	No
MIG-17D	3 NR-23	Yes	4 ALKALI
MIG-17E	3 NR-23	Yes	4 ALKALI
MIG-21A & B	Three Gun Installations	Yes	No
MIG-21C	Two or Three NR-30 (model independence)	Yes	2 ATOLL
MIG-21D	No	Yes	2 ATOLL or 2 ALKALI
MIG-21E	Same as C Model	Yes	2 ATOLL

APPENDIX III

SOVIET AIR-TO-AIR MISSILES

TYPE	GUIDANCE*	WT (LB.)	L (IN.)	WH (LB.)	RANGE (NM)
AA-1 (ALKALI)	BR	200	96	35	2-4
AA-2 (ATOLL)	IR SA	170	110	25	5-6
AA-3 (ANAB)	IR SA	575	160	100	8-12
AA-4 (AWL)	SA	750	160	125	9-11
AA-5 (ASH)	SA	900	200	150	10-16

*BR=Beam Rider; IR=Infrared; SA=Semi-active Radar

APPENDIX IV

COMPARISON DATA MIG-21 vs. F-105/F-4C

	MIG-21C/E	F-105	F-4C
COMBAT RADIUS	240 NM	570 NM	525 NM
T.O. GROSS WEIGHT (LB)	17,150	47,000	58,000
FUEL (GAL)	773	2,510	3,312
T. O. GND RUN SL (FT)	4,500	4,450	3,030
RATE CLIMB/SL (FPM)	7,600	5,710	9,170
SERVICE CEILING (100 FPM) (Mil Pwr)	42,900	32,750	36,900
SPEED (Mach)	2.05	2.08	2.19
MAX SPEED SL (KTS)	595	750	720
MAX ALT. (FT) (Serv Ceiling-Clean AB)	62,000	45,000	60,000
ARMAMENT:			
GUNS	1X30MM(NR30)	1X20MM(M-61)	(2) SUU-16A 20-MM gun pod
AMMO	60 RDS	1075 RDS	1200 RDS
ROCKETS	32X57MM FFAR	114x2.75" FFAR or 16X5" FFAR	15 LAU-3A (19 ea) or 15 LAU-10A (4 ea)
BOMBS	1100 LB (110,220,550,1100)	16x750 LB	19x750 LB
MISSILES	2 ATOLL	4xAGM-12B or 4xAIM-9B	4 Sparrow (AIM-7) or 4 Sidewinders (AIM-9)

APPENDIX V

MISSILE PERFORMANCE

ALKALI Missile

Max Velocity	1.7 Mach + launch aircraft speed
Accuracy (CEP)	20 feet
Attack Capability	Lead pursuit
Compatible Carrier	Fresco-D, E Farmer Fishbed-D Fishpot-B

ATOLL Missile

Max Velocity	2.0 Mach (Computed over launch velocity)
Accuracy (CEP)	20 to 35 feet
Attack Capability	Lead pursuit
Compatible Carrier	All Fighter aircraft

APPENDIX VI

COMBAT LOSSES
(Over NVN and Laos)
1 January 1965-30 April 1967

Cause	Combat Losses	% of Total
Ground Fire	436	68.0%
SAM	52	8.1%
MIG	16	2.5%
Unknown	137	21.4%

USAF AIRCRAFT LOSSES AS A RESULT OF MIGs

	Aircraft Involved	Losses	Total
CY 65			
4 Apr	4-MIG-17	2 F-105	2 F-105
CY 66			
29 Apr*	Unknown	1-A-1	1-A-1
19 Jul	4-MIG-17	1-F-105	2-F-4
29 Jul	Unknown	1-RC-47	3-F-105
16 Sep*	Unknown	1-F-4C	1-RC-47
21 Sep	3-MIG-17	1-F-4C	
5 Dec	2-MIG-17	1-F-105	
14 Dec	2-MIG-17	1-F-105	
CY 67			
19 Apr	2-MIG-17	1-A-1	2-F-4C
28 Apr	1-MIG-21	1-F-105	1-A-1
30 Apr	Unk-MIG-21	3-F-105	4-F-105
12 May	2-MIG-17	1-F-4C	
20 May	15-MIG-17	1-F-4C	

* Probable losses to MIGs.

APPENDIX VII

CHANGES IN AIR ORDER OF BATTLE
February-June 1967

MIG-17/15	12 February	6 March	19 March	2 April	23 April	30 April	7 May	14 May	21 May	28 May	11 June
Phuc Yen	29	29	28	28	28	24	13	6	6	6	15
Kep	22	22	12	9	4	12	13	18	11	10	7
Hanoi/Gia Lam	16	16	21	21	25	20	14	24	26	18	18
Haiphong/Cat Bi	2	2	2	2	2	2	2	2	0	0	0
Haiphong/Kien An	2	2	2	2	0	0	0	0	0	0	0
Hoa Lac	2	0	5	7	9	8	14	6	4	1	1
	73	71	70	69	68	66	56	56	47	35	41

MIG-21	1 February	30 April	7 May	14 May	28 May	18 June
Phuc Yen	18	16	20	16	12*	15
Kep	-	-	-	-	-	-
Haiphong/Gia Lam	-	-	3	3	3	-
Haiphong/Cat Bi	-	-	-	-	-	-
Haiphong/Kien An	-	-	-	-	-	-
Hoa Lac	-	-	-	-	-	-
	18	16	23	19	15	15

* Change was probably four dummies parked on the ramps.

APPENDIX VIII

USAF AIR-TO-AIR MISSILES

TYPE	GUIDANCE*	FCS	WT (LBS)	L (IN)	DIA (IN)	WH (LBS)	FUZE	MIN/MAX R N MI
AIM-4D (IR FALCON)	IR		134	80	6.4	7	CONT	.3/3
AIM-7E (SPARROW IIIb)	S.A.	AMCS	445	144	8	71	PROX	.7/12
AIM-9B (SIDEWINDER 1a)	IR		164	111	5	12.5	CONT + PROX	.5/3
AIM-47 (FALCON GAR-9)	S.A.	ASG-18	820	150	13.5	75	PROX	5-10/45
AIM-54A (PHOENIX)	S.A. HOJ M.A.R	AWG-9	1000	156	15	170	PROX	.3/50

* IR=Infrared; S.A.=Semi-active Radar; HOJ=Home-on-Jam; M.A.R.=Missile Active Radar

APPENDIX IX

MIG KILLS BY USAF
23 April - 8 July 1967

AIM-7	TOTAL	% OF TOTAL	F-105*	F-4C
HITS	8	11.1	-	8
PROB HITS	2	2.8	-	2
UNOBSERVED	3	4.2	-	3
MISSES	59	81.9	-	59
	72	100.0	-	72
AIM-9				
HITS	10	16.9	3	7
PROB HITS	1	1.7	0	1
UNOBSERVED	6	10.2	0	6
MISSES	42	71.2	8	34
	59	100.0	11	48
CANNON				
HITS	14	50.0	10	4
PROB HITS	2	7.1	2	0
GUN FAILURE	2	7.1	1	1
MISSES	10	35.8	8	2
	28	100.0	21	7

* F-105 does not carry the AIM-7

AIRCRAFT RESULTS

MIG 17

	F-105	F-4C
AIM-7	0	6
AIM-9	3	4
AIM-4	0	0
CANNON	6	3
	9	13

MIG 21

AIM-7	0	2
AIM-9	0	2
AIM-4	0	0
CANNON	0	2
	0	6

TOTAL MIG KILLS - 28

MIGs DAMAGED - 8

GLOSSARY

AAA	Antiaircraft Artillery
AAM	Air-to-Air Missile
A/C	Aircraft
AI	Airborne Intercept
AGL	Above Ground Level
AOB	Air Order of Battle
BDA	Battle Damage Assessment
C-BAND	Range of frequencies from 3,400 to 6,200 megacycles
ECM	Electronic Countermeasures
ELINT	Electronic Intelligence
EW	Early Warning Radars
FFAR	Folding Fin Aircraft Rocket
FIRE CAN	Soviet AAA fire control radar
GCI	Ground Controlled Intercept
IFF	Identification Friend or Foe
JCS	Joint Chiefs of Staff
KCAS	Knots Calibrated Air Speed
KIAS	Knots Indicated Air Speed
KT	Knots
KTAS	Knots True Air Speed
L-BAND	Range of frequencies from 390 to 1,550 megacycles
LOC	Line of Communications
MIG CAP	MIG Combat Air Patrol
NM	Nautical Mile
NVN	North Vietnam
NVNAF	North Vietnamese Air Force
RESCAP	Rescue Combat Air Patrol
RHAW	Radar Homing & Warning
S-BAND	Range of frequencies from 1,500 to 5,200 megacycles
SAM	Surface-to-Air Missile
TOT	Time on Target
WH	Warhead